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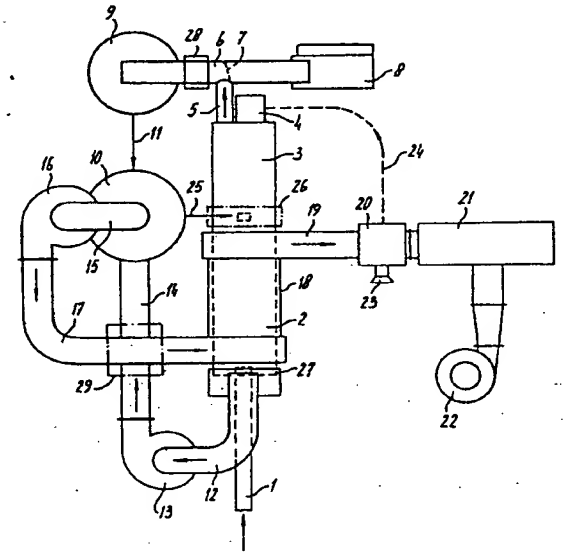
## (54) Process and apparatus for cleansing soil polluted with toxic substances.

(57) The invention relates to a process for cleansing soil polluted with toxic substances having a high temperature of evaporation, said soil being heated in a first rotating kiln (2, 3) to evaporate part of the toxic substances, subsequently is heated in a second kiln (10) of a fluid bed type to a higher temperature, partly using the combustion heat of the already liberated vapours after which the heated soil of the second kiln is supplied to the first kiln to raise the temperature of the soil present in the first kiln. Between the first and second kiln there can be a storage silo (9).

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Process and apparatus for cleansing soil polluted with toxic substances.

The invention relates to a process for cleansing soil polluted with toxic substances, by heating said soil in a first treatment kiln to a temperature which is high enough to evaporate at least part of the toxic substances, the vapours subsequently being burned in a second kiln, and the heat fed in and liberated in the process being used by heat exchange for preheating the cold soil fed into the first kiln, and for preheating the combustion air fed to the kilns, while the soil coming out of the first kiln can be cooled and conditioned, in particular moistened.

Such a process and apparatus are known from Dutch Patent Application 8105677, which has been laid open for inspection. In the case of this known process and apparatus, polluted soil, preferably with water removed by drainage if necessary, is fed to a rotary kiln through which hot gases from a burner are conducted in countercurrent to the direction of movement of the soil, during which process the soil is heated to about 250 deg.C, as a result of which the contaminants in it evaporate. The soil coming out of the rotary kiln is cooled and rendered reusable by moistening and, if necessary, by adding fertilisers.

The vapours or gases coming out of the rotary kiln go to a second kiln, in which they are burned, following which the combustion gases liberated are used through heat exchange for preheating the still cold soil and subsequently for preheating the combustion air of the kilns. The heat exchange takes place in an indirect manner through the fact that the gas flows coming out of the second kiln flow through a jacket and pipe system of the rotary kiln.

Through the recovery of energy by burning the vapours and gases which are liberated during heating of the soil, this known process is technically and economically feasible and is therefore satisfactory in very many cases.

There are, however, an increasing number of contaminants which do not evaporate satisfactorily or at all at 250 deg.C, and which therefore remain in the soil following use of the known process and apparatus, so that the soil must still be regarded as polluted.

If the polluted soil were to be heated to a higher temperature in the same rotary kiln, this would cost a great deal of energy which is not recovered, while the yield from the recovery of energy from the flue gases of the second kiln would be greatly reduced. The known process and apparatus are therefore not suitable for cleansing soil containing toxic substances for the removal of which a much higher temperature is required.

The object of the invention is now to produce a process in which this is economically possible.

This object is achieved according to the invention in that soil coming from the first kiln is taken to a second kiln and heated therein to a considerably higher temperature, partly by using the combustion heat of the vapours from the first kiln, and the soil coming from this second kiln is taken to the first kiln at such a point that the soil in it is raised - partly by the heat of the soil coming from this second kiln - to the temperature required in this first kiln for evaporating toxic substances. In this way, by using the combustion heat of the vapours and gases fed to the second kiln, it is possible for the preheated soil coming from the rotary kiln to be heated in the second kiln to the much higher temperature of, say, 800 to 1000 deg.C, and the recovery of energy producing an acceptable yield is obtained by taking the

highly heated soil from the second kiln to the first kiln at a suitable point, which will be somewhere between the beginning and end of the rotary kiln, depending on the extent to which the cold soil has already been preheated by the gases coming out of the second kiln. Soil at a high temperature, but completely cleansed, is therefore mixed with still polluted soil, as a result of which the latter is very quickly raised to the desired temperature.

According to the invention, soil coming from the first kiln can also be conveyed to a third kiln, in which it is heated to a considerably higher temperature, and the soil from this kiln is taken to the first kiln at such a point that - partly through the heat of the soil coming from the third kiln - the soil in it is raised to the temperature required in the first kiln for the evaporation of toxic substances. In this process, three kilns are therefore used, one for heating the soil to a temperature of,say, 250 deg.C (the first kiln), one for the combustion of the gases and vapours liberated in the process (the second kiln), and one for heating of the soil to a high temperature (the third kiln).

If one is dealing with soil containing only contaminants which evaporate at the relatively low temperature (250 deg.C), it will be adequate to use the known process. However, if the soil contains heavier contaminants, then the process according to the invention is used.

In practice, one will come up against varying soil compositions as far as pollution is concerned. One can then use the two processes in turn, and in this case it is important that according to the invention the soil coming out of the first kiln and going to the second or third kiln can be stored in the interim, in order to be able to discharge in purified form the slightly polluted soil which has been raised to temperature, for example using the heat from the soil coming from the second kiln, in which case the contents of the temporary store, for example a

silo which is preferably insulated, decrease.

If one then has to deal again with heavily polluted soil, the process according to the invention is used with interim storage, in other words, the silo is filled with the soil coming from the first rotary kiln, from which soil is conveyed to the second or third kiln as required.

When soil is heated to a high temperature in the second or third kiln, there could be a liberation of vapours which are inadequately broken down, despite the high temperature therein.

According to the invention, it is possible to subject these vapours or gases to after-burning, where the temperature is even higher. This after-burning can take place in a separate or fourth kiln, but it preferably takes place by conveying to the second kiln the gases liberated during the heating of soil to a high temperature in the third kiln.

In the apparatus for use of the process according to the invention, the second or third kiln is preferably a fluidised bed kiln, which makes intensive heating of all soil particles possible.

According to the invention, the output can be improved even further if a heat exchanger is located between the discharge pipe of the second and/or third kiln and the vapour pipe running from the first to the second kiln.

The invention will now be explained in greater detail with reference to the drawings.

Fig. 1 is a diagrammatic sketch of an apparatus according to the invention, for using the process according to the invention.

Fig. 2 is a variant of Fig. 1.

Fig. 3 is a variant of Fig. 2.

The drawing in Fig. 1 shows a rotary kiln with a front section 1 and a rear section 2, said rotary kiln being able to rotate in the known manner, by means not shown ,about its longitudinal axis, and being designed in such a way that the soil fed into it moves in the longitudinal direction through the drum, for example through a sloping arrangement and/or helical blades on the inside wall of the drum.

The infeed takes place via a conveyor shown schematically at 1.

At 4 there is a burner, for example an oil burner, by means of which the kiln is heated.

The soil emerging from the rear section 3 of the rotary kiln passes via a conveyor chute 5 to a distributor device 6 which, depending on the setting of the valve 7, conveys the soil emerging from the rotary kiln either to a conditioning device 8 or to a storage silo 9.

At 10 there is a fluidised bed kiln to which soil may be conveyed by means of a conveyor 11 (not shown in detail) from the silo 9.

The hot gases and vapours which are liberated from the soil in the rotary kiln 2,3 pass via the pipe 12 and a cyclone dust collector 13 via the pipe 14 to the kiln 10 and are burned there. The gases and vapours from the rotary kiln thereby produce part of the energy needed to heat the soil conveyed from the silo 9 to the kiln 10 to a temperature of 800 to 1000 degrees.

The gases coming from the kiln 10 pass via the pipe 15 and a cyclone dust collector 14 through the pipe 17 to the inlet

section or front section 2 of the rotary kiln. From there they are taken via the indirect transfer system 18, consisting of a double wall and pipes, to the collection channel 19. In the indirect transfer system 18 of the front section 2 of the rotary kiln there is heat transfer from the hot gases coming from the kiln to the still cold soil being fed in by the conveyor apparatus 1.

The gases in the pipe 19 subsequently flow through a heat exchanger 20 and a dust collector 21 and from there via a fan 22 to a chimney. The heat exchanger 20 has an inlet 23 for air which flows via a pipe 24 to the burner 4 and if necessary to the kiln 10, so that these receive preheated air.

The infeed of soil from the kiln 10 to the rotary kiln 2,3 is schematically illustrated by the line 25. This infeed can take place by means of a compartment which is situated between the front section 2 and rear section 3, and which is schematically indicated by 26 and can consist of a stationary ring with a top filling opening, provided that the rotary kiln is designed in such a way that conveyance of the soil over the stationary ring is ensured.

The infeed can, however, also take place at the stationary front plate 27 by means of a conveyor projecting into the drum, and of sufficient length to deposit the soil at the correct point in the kiln.

Instead of the fluidised bed kiln, it is also possible to use two kilns 10a and 10b, as shown in Fig. 2. For heating of the soil to 800 - 1000 deg.C, it is desirable to have a fluidised bed kiln 10a, but it is not necessary for the destruction of the gases and vapours liberated from the first kiln 2,3. The latter can also take place in a known manner in an ordinary chamber kiln 10b.

While, therefore, according to Fig. 1, the gases and vapours liberated in the first kiln are added to the process in the fluidised bed kiln 10, a split occurs according to Fig. 2, in that for the after-burning of the liberated gases and vapours from the first kiln, a kiln 10b (the second kiln) different from the fluidised bed kiln 10a (the third kiln) required for heating of the soil to a high temperature is used. This may be desirable for economic or operational reasons.

The gases leaving the two kilns 10a and 10b are combined and fed via pipe 17 to the heat exchanging section 18 of the first kiln 2.

The variant of Fig. 3 is a solution to the situation where the vapours or gases coming from the fluidised bed kiln 10a still contain a certain amount of contaminants which have not been destroyed. In order also to destroy these contaminants, e.g. dioxins, an even higher temperature is required.

According to Fig. 3, these vapours or gases are now conveyed to the kiln 10b, which is known per se, and are raised to a higher temperature, following which they are discharged via the pipe 17.

Example:
Soil polluted with, for example, high-molecular polycyclic aromatic compounds is dug up after ground water has been removed as far as possible by drainage. Following sieving for the removal of coarse components such as gravel, the soil is conveyed uniformly to and conducted through the rotary kiln 2,3 and heated to 250 deg.C or more, for example 450 deg.C.

On leaving the drum 2,3, the soil passes through a control valve 7 and a sieve such as the sieve 28 for separation of granular material which is larger than 20 mm and is temporarily stored in the silo 9.

When the silo is full, one proceeds at the infeed side of the drum in the front section 2 to feed in soil which is contaminated with for example, high-molecular polycyclic aromatic compounds.

At the same time, one starts to feed in soil from the silo 9 to the fluidised bed kiln 10 or 10a.

When the soil has been heated therein to, say 800 deg.C, this highly heated soil is uniformly discharged and taken via a feed device 25, 26 to the transition area between the indirectly preheated section 2 of the rotary kiln and the directly heated rear section 3 of the drum.

Here, mixing takes place with the already partially preheated, still contaminated soil, which can have a temperature of, for example, 100 deg.C there. Through the mixing with the correct quantity of highly heated soil from the kiln 10, the desired end temperature of approx. 250 deg. C can be achieved.

The soil now leaving the rotary kiln 2,3 can be taken to a mixing or conditioning device 8, after resetting of the valve 7, where it is cooled and moistened through the infeed of water.

As soon as the silo 9 is almost empty, one switches over again to the infeed of soil polluted with high-boiling contaminants, which are then taken again to the intermediate silo 9.

All gases liberated pass through the fluidised bed kiln 10 or through the chamber kiln 10b and thereafter pass through heat exchangers and cyclone dust collectors and/or filters before discharge to the chimney takes place.

At 29 there is a schematic illustration of a heat exchanger, by means of which heat from the combustion gases from the kiln 10 or

10a and 10b can be transferred to the gases or vapours coming out of the rotary kiln 2,3 and going to the kiln 10 or 10 b to be burned there, said gases or vapours therefore reaching the kiln 10 or 10b at a higher temperature due to the heat transfer.

## Claims

1. Process for cleansing soil polluted with toxic substances, by heating said soil in a first treatment kiln to a temperature which is high enough to evaporate at least part of the toxic substances, said vapours subsequently being burned in a second kiln, and the heat fed in and liberated in the process being used by heat exchange for preheating the cold soil fed into the first kiln, and for preheating the combustion air fed to the kilns, while the soil coming out of the first kiln can be cooled and conditioned, in particular moistened, characterised in that soil coming from the first kiln is taken to a second kiln and heated therein to a considerably higher temperature, partly by using the combustion heat of the vapours from the first kiln, and the soil coming from this second kiln is taken to the first kiln at such a point that the soil in it is raised – partly by the heat of the soil coming from this second kiln – to the temperature required in this first kiln for evaporating toxic substances.

2. Process for cleansing soil polluted with toxic substances, by heating said soil in a first treatment kiln to a temperature which is high enough to evaporate at least part of the toxic substances, said vapours subsequently being burned in a second kiln, and the heat fed in and liberated in the process being used by heat exchange for preheating the cold soil fed into the first kiln, and for preheating the combustion air fed to the kilns, while the soil coming out of the first kiln can be cooled and conditioned, in particular moistened, characterised in that soil coming from the first kiln is taken to a third kiln and heated therein to a considerably higher temperature, and the soil coming from this kiln is taken to the first kiln at such a point that the soil in it is raised – partly by the heat of the soil coming from the third kiln – to the temperature required in this first kiln for evaporating toxic substances.

3. Process according to Claim 1 or 2, characterised in that the gases from the second or third kiln which are liberated during heating of the soil to a high temperature are subjected to after-burning.

4. Process according to Claim 1, 2 or 3, characterised in that the soil coming from the first kiln and going to the second or third kiln is stored in the interim.

5. Process according to Claim 1, 2, 3 or 4, in which heating to approx. 250 deg.C takes place in the first kiln, characterised in that there is heating to 800 to 1000 deg.C in the second or third kiln.

6. Apparatus for carrying out the process according to one or more of the preceding claims, comprising a first countercurrent kiln designed as a rotary kiln, characterised in that the second or third kiln is a fluidised bed kiln.

7. Apparatus according to Claim 6, characterised in that the interim storage takes place in an insulated silo.

8. Apparatus according to Claim 6 or Claim 7, characterised in that a heat exchanger is provided between the discharge pipe of the second and/or third kiln and the vapour pipe coming from the first to the second kiln.

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Fig-1

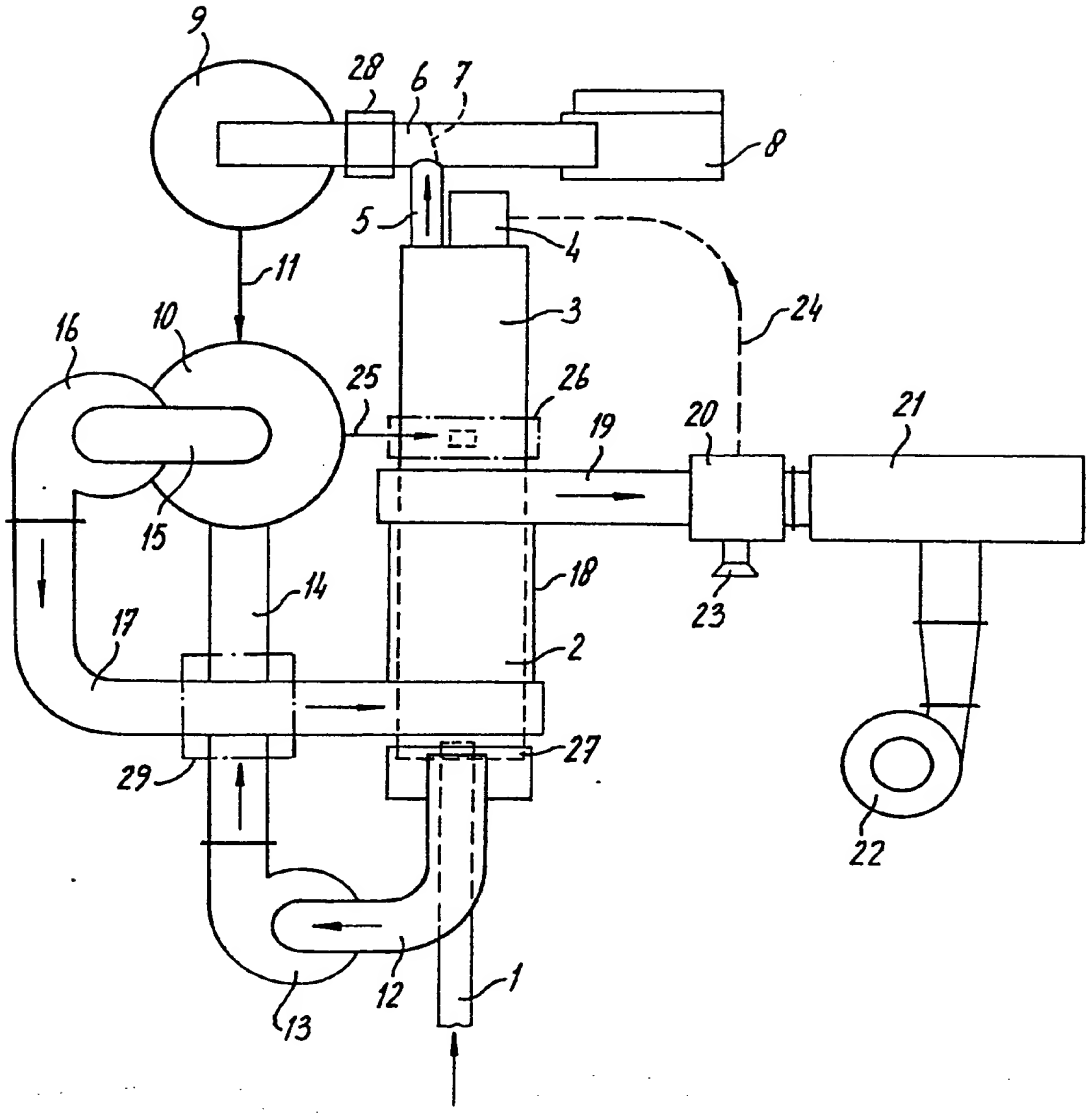

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Fig-2

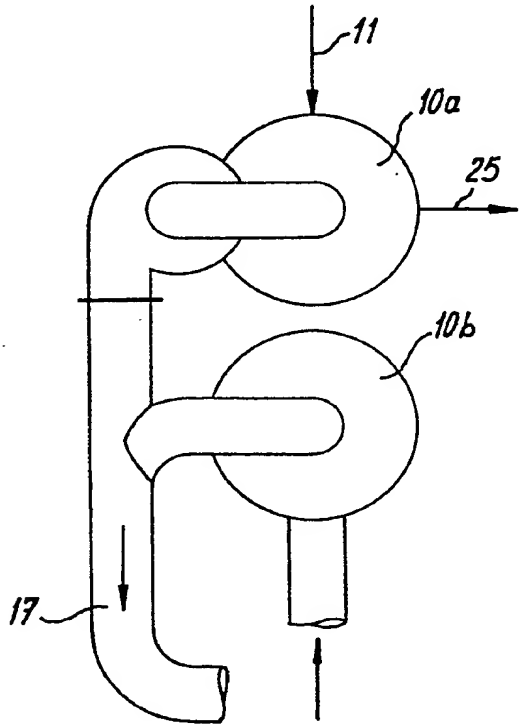

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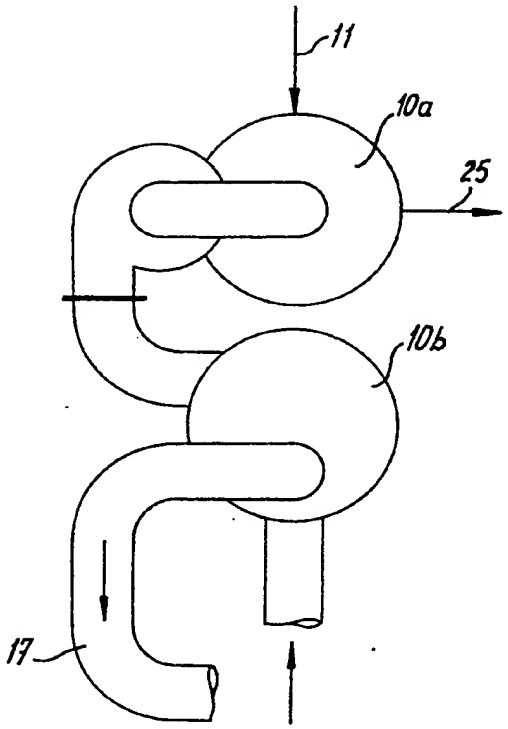
Fig-3



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# EUROPEAN SEARCH REPORT

0155022
. Application number

EP 85 20 0152

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| A | DE-A-3 216 771 (STEVIN B.V.) * Page 5, line 11 - page 9, last line; figures 1,5,6 * & NL - A - 8 105 677 (Cat. D) | 1,2,6 | B 09 B 5/00<br>F 23 G 5/027 |
| A | FR-A-2 369 505 (PERLMOOSER ZEMENTWERKE) * Page 4, line 21 - page 5, line 11; page 13, line 24 - page 15, line 5; figure * | 1,2,6 | |
| A | DE-B-1 247 532 (C. ROSENBERGER) | | |
| A | FR-A-1 425 223 (WIBAU) | | |
| A | FR-A-2 361 606 (WEST'S PYRO) | | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| A | DE-A-3 122 395 (APELT INDUSTRIEOFENBAU) | | B 09 B<br>F 23 G<br>A 62 D<br>A 01 G<br>E 01 H |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 05-06-1985 | LAVAL J.C.A |

CATEGORY OF CITED DOCUMENTS

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